REMARKS

In view of the above amendments and following remarks, reconsideration of the objections and rejections that are contained in the Office Action of April 25, 2011 is respectfully requested.

Drawing Objections

In section 1 on page 2 of the Office Action, the Examiner objected to the contact angle θ, referenced in the claims, not being illustrated. Accordingly, a new figure 2 has now been provided which illustrates angle θ.

The Examiner further objected to the claims referring to an elastic pressure that is applied in axial direction so as to separate the inner member and the retainer. This feature is not exactly a feature, as it is a force (elastic pressure). However, in any case claim 1 has been amended to refer to the elastic member that creates the force, and such elastic member is illustrated, for example, in fig. 3 by reference number 54.

Reference character A has been deleted as a reference to the constant velocity joint as a whole. This should remedy the double usage of A referred to by the Examiner in subparagraph B on page 2.

The Examiner also argued that the drawing should include reference character PCD_{BALL}. However, PCD_{BALL} is not a reference character but is a reference to the pitch circle diameter of the balls in the joint. In another words, it designates a measurement or characteristic, and not an item or an element per se.

The Examiner also noted that the drawings include reference characters 2c and 5b. However, a review of the drawings does not indicate where these are found, and the Examiner is requested to indicate where the reference characters can in fact be found.

The Specification

A number of minor editorial changes have been made to the specification, in view of the Examiner's request, and so as to make minor formal changes to the specification. No new matter has been entered. The specific items noted by the Examiner in paragraph 2 on page 3 of the Office Action have been addressed.

Formal Matters in the Claims

Claims 3 and 11 were objected to by the Examiner in section 5 on page 4 of the Office Action. However, it is noted that, at this time, both of these claims have been canceled. The language of prior claim 3 has in fact been incorporated into claim 1 and has been amended to address the Examiner's concerns.

The various issues raised by the Examiner in section 7 on pages 4 and 5 of the Office Action have also been remedied by the above amendments to the claims.

Rejections Made by the Examiner

Examiner rejected claims 1-3 and 11 as being unpatentable over Yamazaki, US 2003/3083135 in view of Sone, US 6,120,382. Claims 4 and 12-14 were rejected over these same references and further in view of Ouchi, US 2001/0021671. Claims 5-7 and 15 were rejected over the same two references in further view of Nakagawa, US 2002/0022528. Lastly, claims 8-10 and 16 were rejected as being unpatentable over Yamazaki and Nakagawa. However, it is respectfully submitted that the present invention, particularly as now amended above, clearly patentably defines over Yamazaki as well as the secondary references that were cited by the Examiner.

Claim 1 has been amended above to recite an elastic member applying an elastic force in an axial direction between the inner member and the retainer in order to press the balls toward a narrower side of the wedge-shaped ball tracks. This language is clearly supported by the specification, noting for example the descriptions in the specification on page 25, line 19, to page 26, line 6.

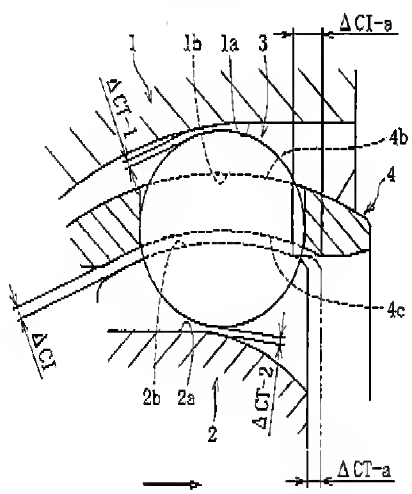
Further, as shown in fig. 1, a center O1 of a track groove 1a of an outer member 1 with respect with spherical center of the inside diameter surface 1b, and a center O2 of a track groove 2a of an inner joint member 2, with respect to a spherical center of an outside diameter surface 2b, are offset oppositely to each other at the same distance F in the axial direction; in other words, the centers O1 and O2 are on opposite sides of the spherical center of the inner and outer diameter surfaces. This is seen in fig. 1, and this results in the ball track that is formed by track grove 1a and track groove 2a being in the shape of a wedge that enlarges in one axial direction, particularly, in the direction of the opening side of the joint in the example illustrated in the drawing figures.

A compression coil spring 54, which is an elastic member, is a source of elastic force that presses a ball of 53 toward an inner most side of the outer member 1, in other words, toward the narrower side of the ball track.

Thus the present invention intends to provide a six-ball fixed-type constant velocity universal joint in which rotational backslash is restrained by an elastic force of an elastic member that acts to clear the clearances between the ball and the wedge-shaped ball track.

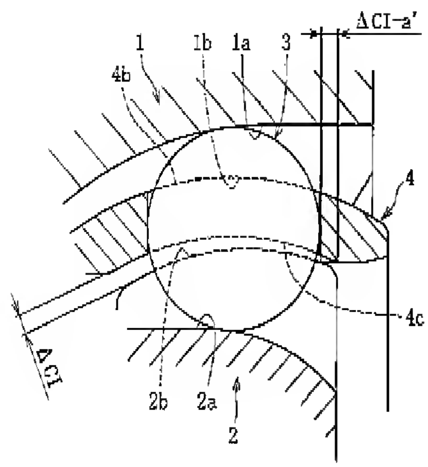
Usually in this type of the constant velocity universal joint, as shown in reference figure 1 below, there are clearances ΔCT-1 and ΔCT-2 between the track groove 1a of the outer member 1 and the ball 3, and between the track groove 2a of the inner member 2. The sum of the clearances ΔCT-1 and ΔCT-2 is the track clearance between the ball track and the ball.

[Reference Figure 1]



The reference figure 2 below shows the state in which the track clearance (ΔCT-1 and ΔCT-2) is cleared up by the elastic force to make the ball contact with the ball track.

[Reference Figure 2]



In the present invention, the elastic member applies the elastic force in the axial direction between the inner member 2 and the retainer 4 to press the ball 3 toward the narrower side of the wedge-shaped ball tracks. Therefore the ball 3 elastically contacts the ball track, which restrains rotational backlash of the joint.

The axial clearance, which is derived from the track clearance (ΔCT1- and ΔCT-2), corresponds to the axial displacement ΔCT-a that is required to make the ball contact with the ball track. In addition, there is a spherical clearance ΔCI, which makes the axial clearance ΔCI-a, between the outer spherical surface 2b of the inner member 2 and the inner spherical surface 4c of the cage 4. In order to make the ball always elastically contact with the ball track by making the inner member relatively move in the axial direction with respect to the cage due to elastic force, the axial clearance ΔCI-a must be larger than the axial clearance which corresponds to the axial displacement ΔCT-a. Because, if ΔCI-a is smaller than ΔCT-a, the outer spherical surface 2b of the inner member 2 contacts the inner spherical surface 4c of the cage 4 first, which means the ball cannot contact with the ball track.

The technical object of the present invention is to make the six-ball fixed-type constant velocity universal joint as mentioned above further compact, while securing strength, load capacity and durability. In order to attain such the object, the present invention comprises the ratio r1 within the range of $1.5 \leq r1 \leq 4.0$ and the ratio R1 within the range of $0.109 \leq R10.162$, in combination with such the structure in that axial clearance ΔCI-a between the outer spherical surface 2b of the inner member 2 and the inner spherical surface 4c of the cage 4 is larger than

the axial clearance (ΔCT-a). In the constant velocity universal joint according to the present invention, the amount of the axial movement of the inner member to make the ball always contact the ball track is defined by configuration in the axial cross section of the track grooves of the inner and outer member. The configuration in the axial cross section of the track grooves are defined by the ratio of the offset amount F to PCR, that is the ratio R1, and the smaller value of R1 becomes, the larger the axial movement of the inner member becomes. Thus, it is necessary to control the amount of the axial movement of the inner member with respect to the cage so as to make the ball always contact with the ball track.

The lower limit value 0.109 or R1 is set as a limit value to secure the amount of the axial movement of the inner member with respect to the cage. When the amount of the axial movement becomes larger, the necessary stroke of the elastic member to make the ball elastically contact with the ball track becomes insufficient, so that rotational backlash of the joint cannot be restrained. The upper limit value 0.162 of R1 is set as a limit value to secure the depth of the track grooves. When the offset amount of F becomes large, the amount of the axial movement to make the ball contact with the ball track becomes small. However, the depth of the track groove becomes shallower on the innermost side of the joint, so that strength, load capacity and durability cannot be secured. Thus the ratio r1is set to make the joint compact in cooperation with the ratio R1.

The cited patent publication to Yamazaki, as the Examiner acknowledges, does not disclose the ratio r1 as defined in claim 1 or the ratio R1 as defined in claim 1. However, the Examiner goes on to cite the patent to Sone for the proposition that these ratios, as required by independent claim 1 would be obvious when Yamazaki is considered in view of Sone.

Sone, it should first be noted, discloses an eight-ball fixed-type constant velocity universal joint that is used for a drive shaft, for example. Sone does not include any means for restraining rotational backlash of the joint. Rather, in Sone's joint, there is a small clearance between the inner spherical surface of the cage and the outer spherical surface of the inner member. However, this clearance is not set so as to be larger than the axial clearance between the ball and the ball track.

The present invention, specifically limited to a constant velocity universal joint employing six track grooves with six balls, and having an elastic member for applying the elastic

force, requires the ratio r1, which is the ratio of the pitch circle diameter of the balls to a diameter of the ball, be in a range of 1.5 to 4.0. The Examiner considers this to be met by the limitation in Sone by the discussion in column 2, lines 6 and 40-43. As stated in column 2, the ratio r1 provides a greater degree of strength of the outer joint member, of load capacity and durability of the joint than in a comparative article, and the ratio is preferably 3.5 to 5.0 as noted at the bottom of column 2, lines 58-59.

Thus, it may be seen that there is a slight overlap of the ratio r1 for an eight ball joint in Sone with the ratio r1 for a six ball joint in claim 1 according to the present invention.

In rejecting claim 3, the Examiner also cites Sone for the proposition of the range R1, citing column 3, lines 21-28 and column 4, lines 2-6. As noted, in Sone, if R1 is greater than 0.121, certain problems come up as identified in column 3, and if less than 0.069, certain other problems come up. Thus, again, there is a slight overlap of the ratio R1 between Sone, for an eight ball joint, and the present invention, which is a six ball joint, in that the upper range of 0.121 for Sone is slightly above the lower limit of 0.109 in the present invention.

With the particular ratios r1 being within the range of 1.5 to 4.0, and R1 being within the range of 0.109 to 0.162, in combination with the remaining claimed features, a six-ball fixed-type constant velocity universal joint is being made further compact, while securing sufficient strength, load capacity and durability. In particular, the amount of axial movement of the inner member, to ensure that the balls always in contact with the ball track, is defined by the configuration of the axial cross section of the track grooves of the inner and outer members. A configuration in the axial cross section of the track grooves is defined by the ratio of the offset amount F to PCR, that is to say, the ratio R1. The smaller the value of R1, the larger the axial movement of the inner member becomes, and the lower limit value 0.109 is set as a limit value in order to ensure the amount of axial movement of the inner member with respect to the cage. If the amount of axial movement becomes too large, the necessary stroke of the elastic member is insufficient so that rotational backlash cannot be restrained. Therefore the upper limit value of 0.162 is set.

These considerations are not considerations made by Sone, which as can be seen from column 3, considers the issues of torque reduction, radial movement in the pockets of the cage, circumferential movement in the pockets of the cage, decreased durability and maximum

operating angle. Thus, it can be seen that with the present invention, r1 and R1 have been addressed to different considerations because of the need to address the rotational backlash.

In other words, Sone identifies the ratios r1 and R1 as having importance in certain respects, but not in other respects. There is nothing that suggests to one of ordinary skill in the art, looking at the problems that are addressed by Sone, to optimize values r1 and R1 in Yamazaki, which is a six ball joint and not an eight ball joint, in a way that would arrive at the ratios r1 and R1 as defined in claim 1. Supporting this conclusion is the fact that, in the first place, each of the ratios only slightly overlap. In the second place, Sone is directed to an eight ball joint, and Yamazaki to a six ball joint. Different considerations are involved.

There is thus no basis to conclude that the limitations of claim 1 as now presented would have been obvious from a combination of these two references.

The secondary references cited by the Examiner do not appear to provide any further teachings in this respect, and specific discussion of these references does not appear to be necessary at this time.

As such, it is respectfully submitted that all of claims 1, 2, 4 and 7 as now amended clearly patentably define over Yamazaki, Sone and the remaining references that were cited by the Examiner. Indication of such is respectfully requested.

In view of the above amendments and remarks, it is submitted that the present application is now in condition for allowance, and the Examiner is requested to pass the case to issue. If the Examiner should have any comments or suggestions to help speed the prosecution of this application, the Examiner is requested to contact Applicants' undersigned representative.

Respectfully submitted,

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